Hypolimnetic Aeration System is “Breathing New Life” Into Aurora Reservoir

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Aurora Water

Mobley Engineering

ch2m SM

Aurora 2008 All-America City

Aurora

Presenters and Authors

- Today's Presenter:
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  - David Austin & Paul Swaim (CH2M)
- Additional Project Team Members:
  - Bill Carter & Jason Assouline (CH2M)
  - Steve Fiori, Kevin Linder & Chris Conte (Aurora Water)
- Thanks to all Aurora Water staff who also contributed to the project

Today's Topics

- Aurora Reservoir Water Quality
- Goals & Problem Statement
- Selected Project Details
- Two Year Observations
- Conclusions

Aurora Reservoir

- Colorado front range terminal storage reservoir for City of Aurora, Colorado
- 32,000 Acre-feet
- 820 surface acres
- Constructed in 1990
- Maximum depth – 90 feet
- Max fill water elevation – 5390 feet
- Utilized by two City of Aurora Water Purification Facilities (WPF)
- Important part of the Aurora Water Prairie Waters Project

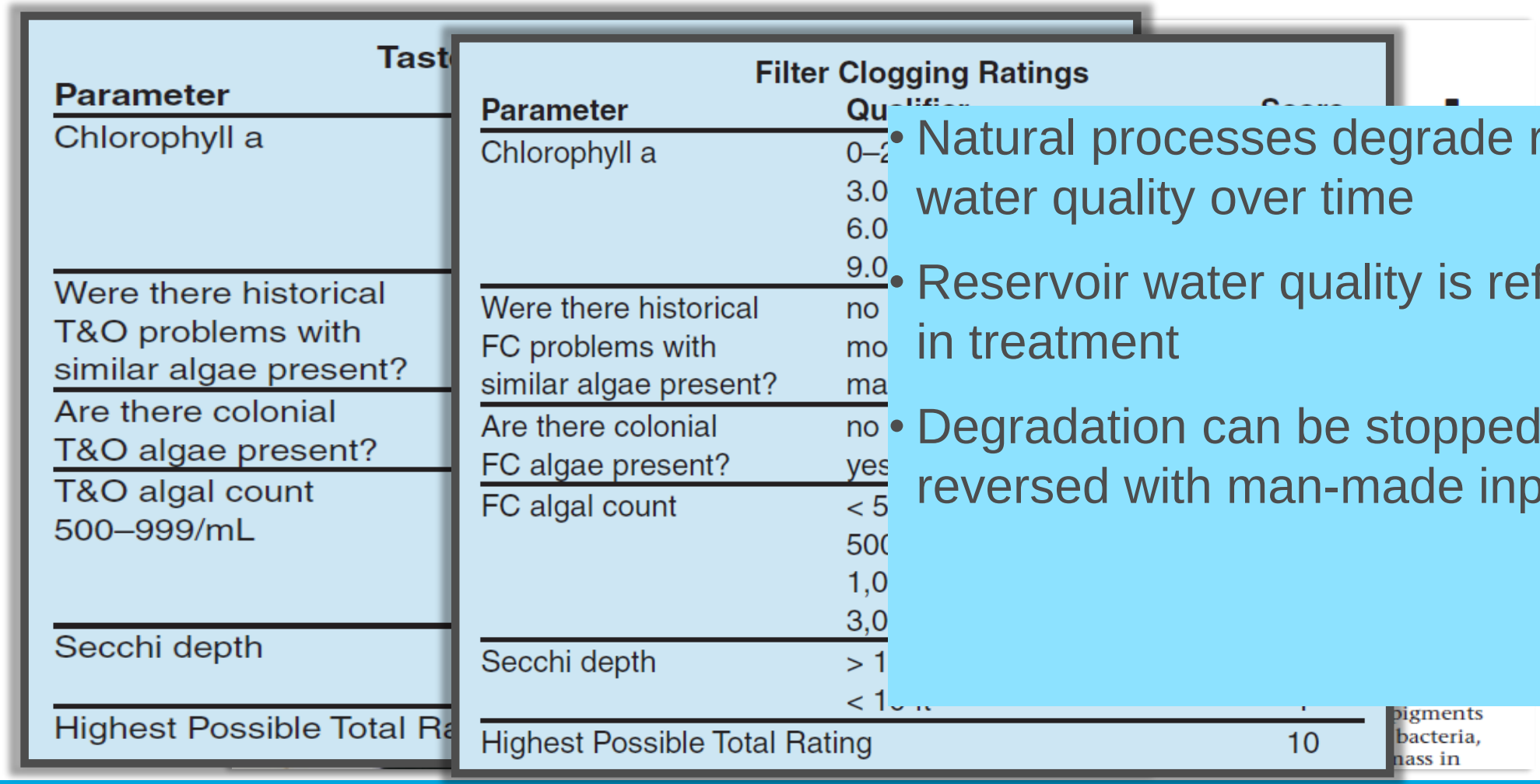
Good water quality in Aurora Reservoir is important to meeting treatment goals at two very different water plants

- Binney WPF
  - 50 MGD
  - Dual treatment train facility:
    - AR train – Conventional treatment, biofiltration
    - SP train – Softening, UV/AOP, biofiltration, and adsorbers
  - Bottom AR water has variable pre-oxidant demand that can be difficult to balance with biofiltration operation

- Wemlinger WPF
  - 80 MGD
  - Direct filtration plant
  - Surface water drawn from AR can contribute a significant solids load on the direct filtration process
  - AR surface water often contains algae that may increase the potential for taste and odor impacts

Aurora Reservoir Water Quality

Storage reservoirs are the first step in the purification process

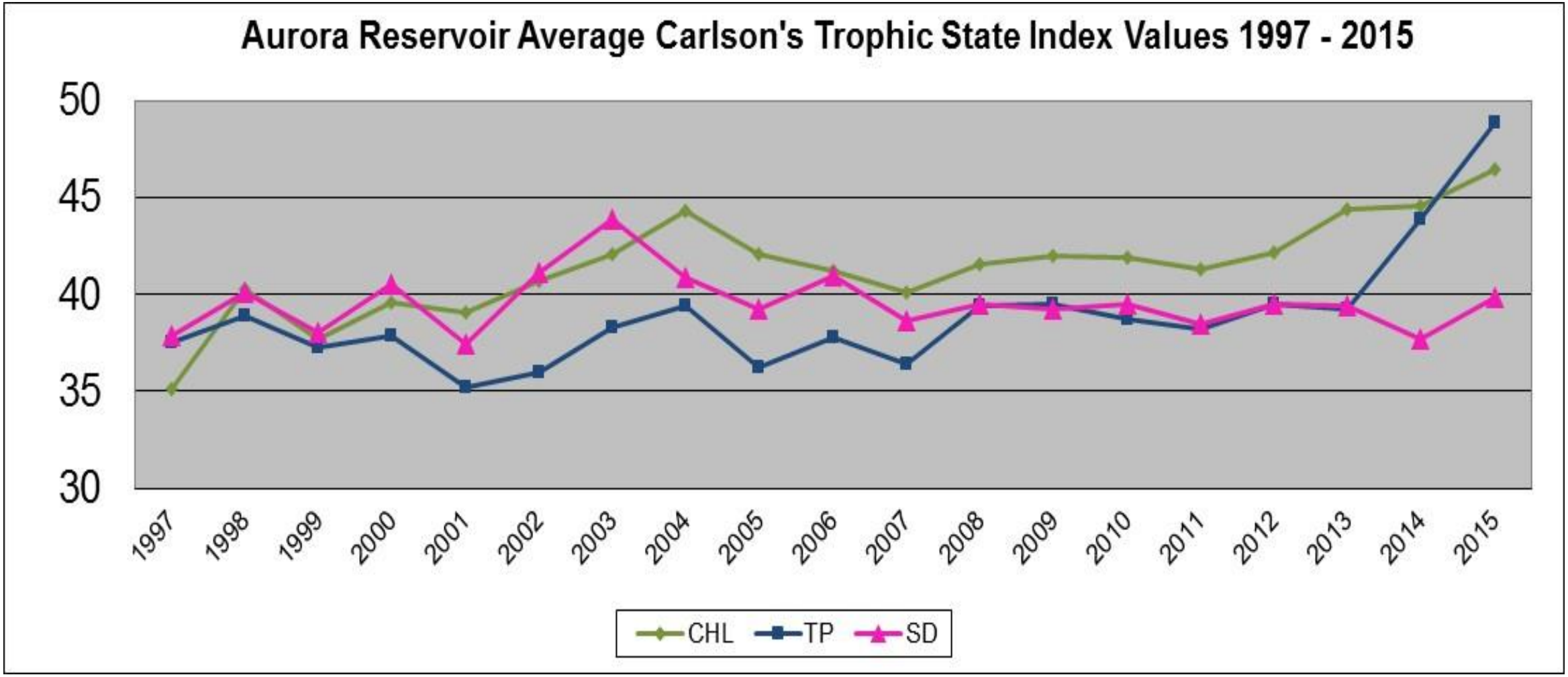


Filter Clogging Ratings

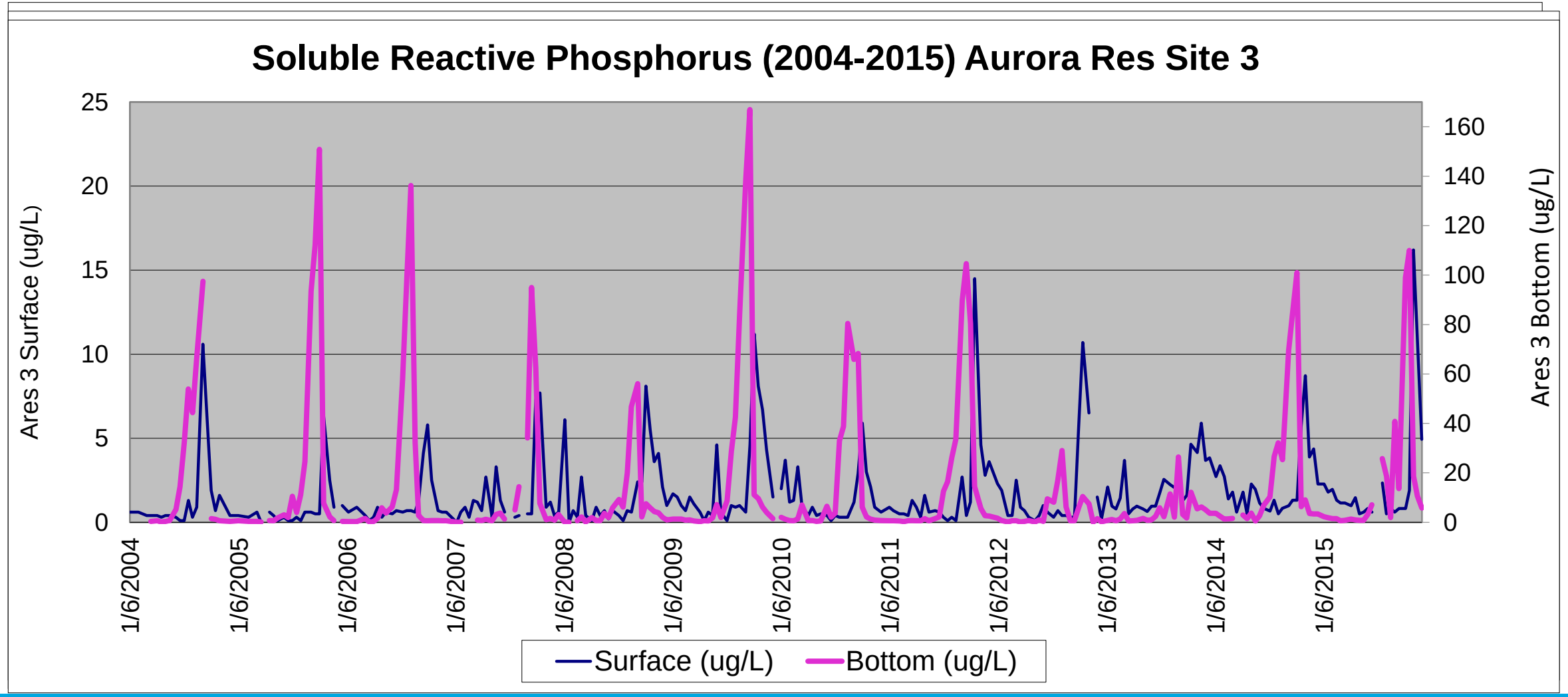
Parameter	Qu
Chlorophyll a	0–2
	3.0
	6.0
	9.0
Were there historical FC problems with similar algae present?	no mo ma
Are there colonial FC algae present?	no yes
FC algal count	< 5 500 1,0 3,0
Secchi depth	> 1 < 1
Highest Possible Total Rating	10

- Natural processes degrade reservoir water quality over time
- Reservoir water quality is reflected in treatment
- Degradation can be stopped and reversed with man-made inputs

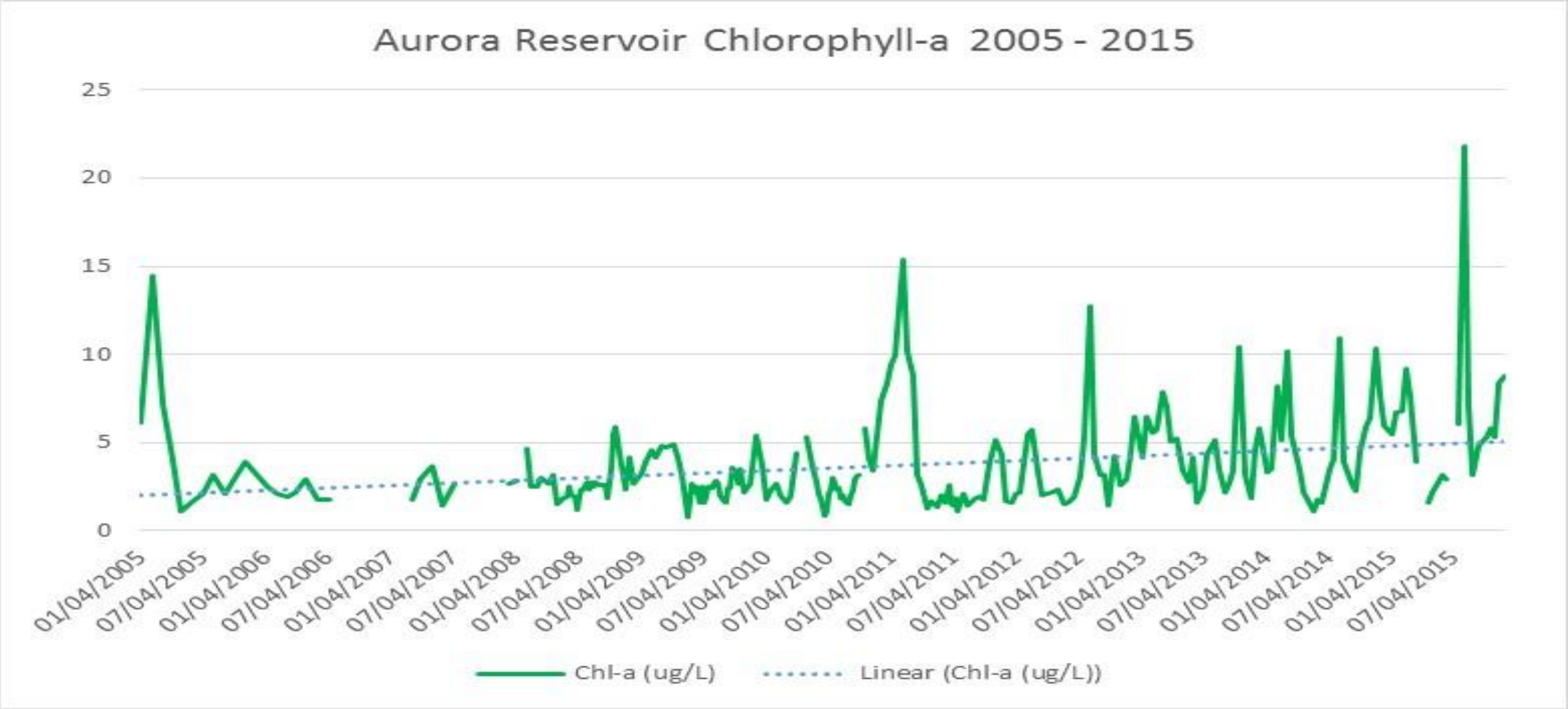
Several reservoir management strategies are in use and have kept TSI values relatively stable…



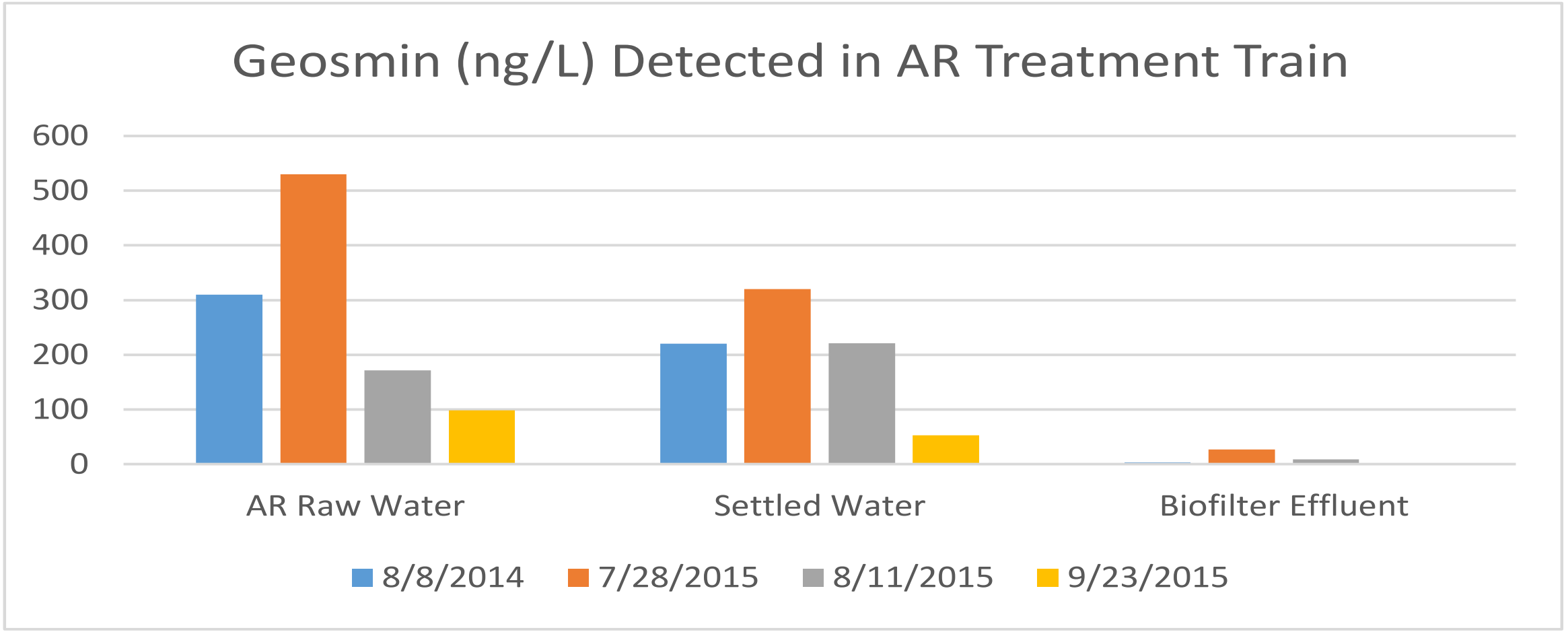
Internal nutrient loading water quality trends are apparent in soluble reactive phosphorus concentrations



In Colorado Front Range reservoirs, sunshine and phosphorus lead to algae growth… and we can't control sunshine



Summer blue-green algal blooms lead to another problem .....taste and odor in treated water



Aurora Reservoir Project: Goals & Problem Statement

Aurora Reservoir project goals

- Higher dissolved oxygen levels in the reservoir hypolimnion
- Less internal release of phosphorus
- Less algae growth
- Better water quality for water treatment at the Binney and Wemlinger WPFs
- An improved fish habitat
- Improved aesthetics within Aurora Reservoir for recreation and other uses

Water quality data analysis shows that this project is the first step to a healthier reservoir

- The root cause of water quality degradation in Aurora Reservoir is the internal loading (release) of phosphorus
- The best way to address this root cause is by raising DO levels
- The data indicates that once we add enough oxygen, the reservoir ecosystem can start to heal itself

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Aurora's water wins in regional taste test again

Which water provider has the best-tasting water in the region? Aurora Water, of course.

Aurora Water beat out 13 other water utilities today at the taste-test at the annual conference of the Rocky Mountain Section of the Amer

It was the second time in three years Au

Aurora to promote its recreational opportunities in the mountains

By Carlos Illescas
The Denver Post

POSTED: 05/13/2014 12:01:00 AM MDT | UPDATED: ABOUT 3 HOURS AGO

ADD A COMMENT

Chris Hernandez of Lakewood fishes at Spinney Mountain Reservoir on Friday. Aurora wants to promote its mountain properties, including Spinney, and create a mountain parks system similar to Denver's. (Hyoung Chang, The Denver Post)

"A lot of people don't even know these opportunities exist," said Marshall Brown, director of Aurora Water. "Other entities have gone out there and publicized what they have. We actually have done some of that; we just haven't done a good job of publicizing that."

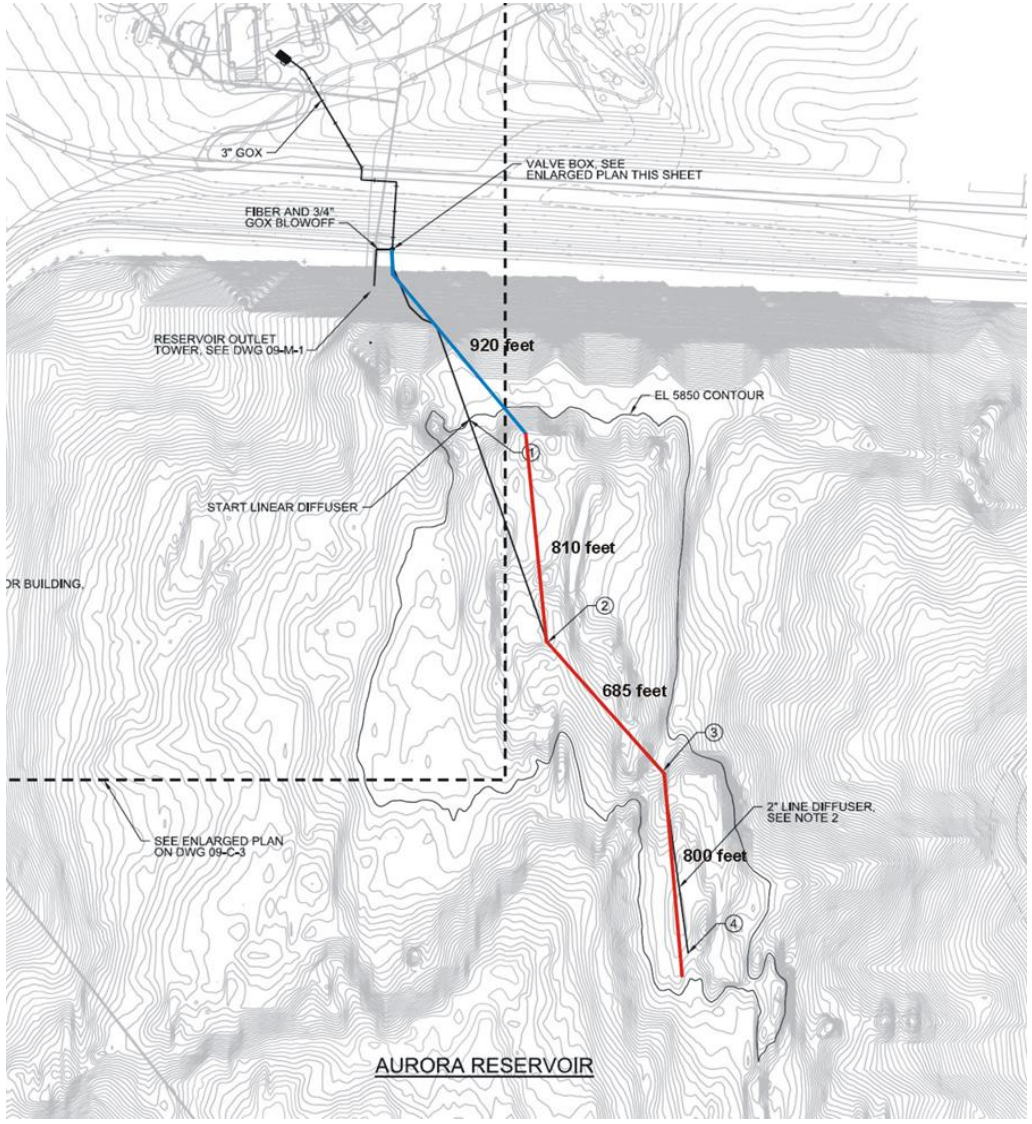
Selected Project Details

Aurora Reservoir aeration project provides maximum benefits at minimum cost

- Study completed in 2014 included cost-benefit analysis of in reservoir alternatives for Aurora Reservoir
- Ballasted linear diffuser with pure oxygen was selected as the most beneficial and least costly approach
- Low bid price less than Engineer's estimate: ~$1M
- Completed installation and system testing in fall 2015
- Began operation full-time in spring 2016

Project details

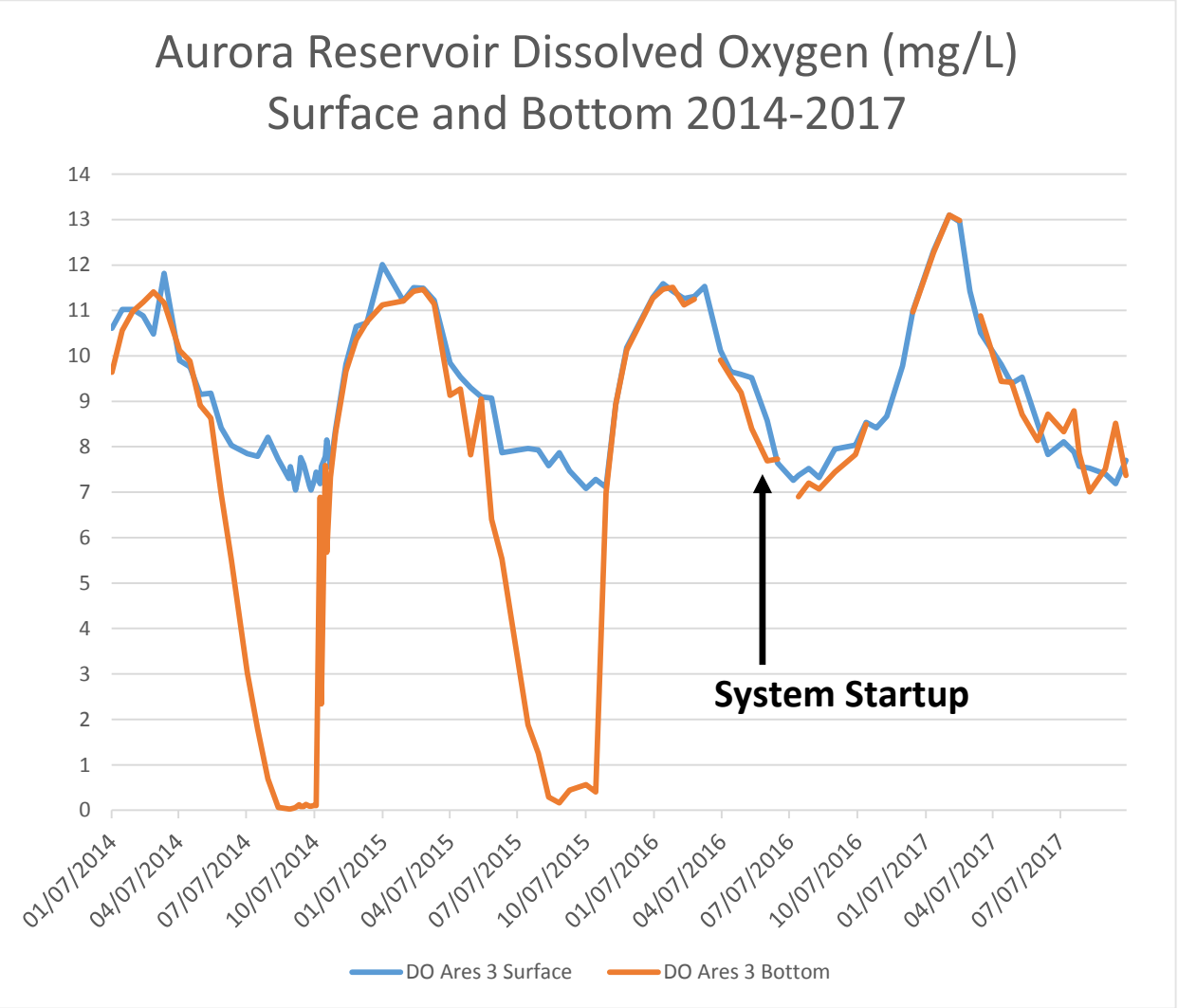
- Oxygen Demand
  - Design hypolimnion volume: 8,270,000 m3
  - Mean depletion rate: 0.0001 kg/m3/d
  - HOD 827 kg O2/d
- Reservoir Placement
  - Single line in center of deep zone
  - Even distribution of velocity gradients
  - Even distribution of DO
- Specs
  - Diffuser length - 2,300 feet
  - Supply line length – 700 feet
  - Diffuser elevation – 5,835 to 5850 feet
  - Maximum O2 flow – 42 scfm
  - Normal O2 flow – 20 scfm



Two Year Observations

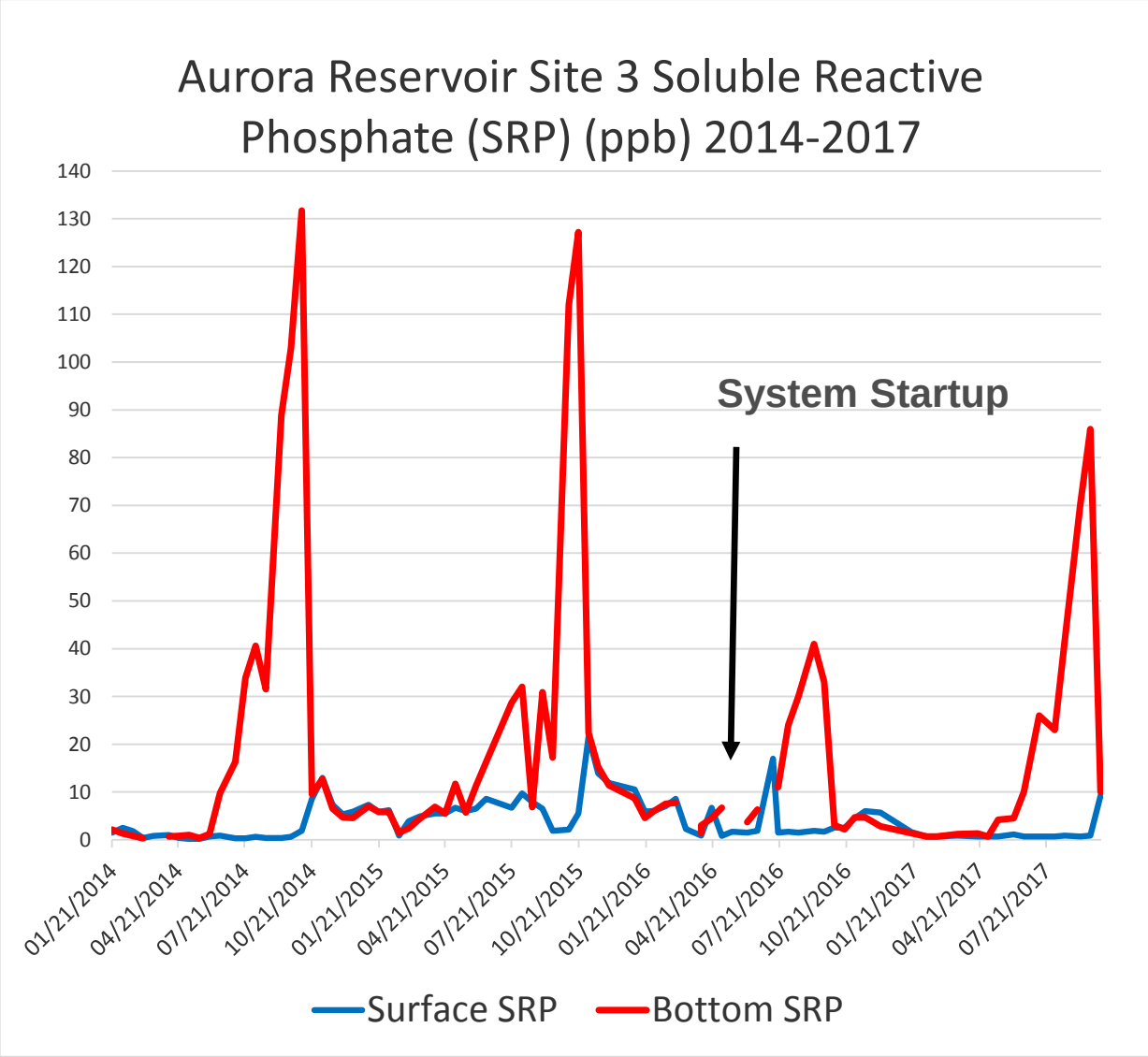
Goal # 1: Higher dissolved oxygen levels in the reservoir hypolimnion

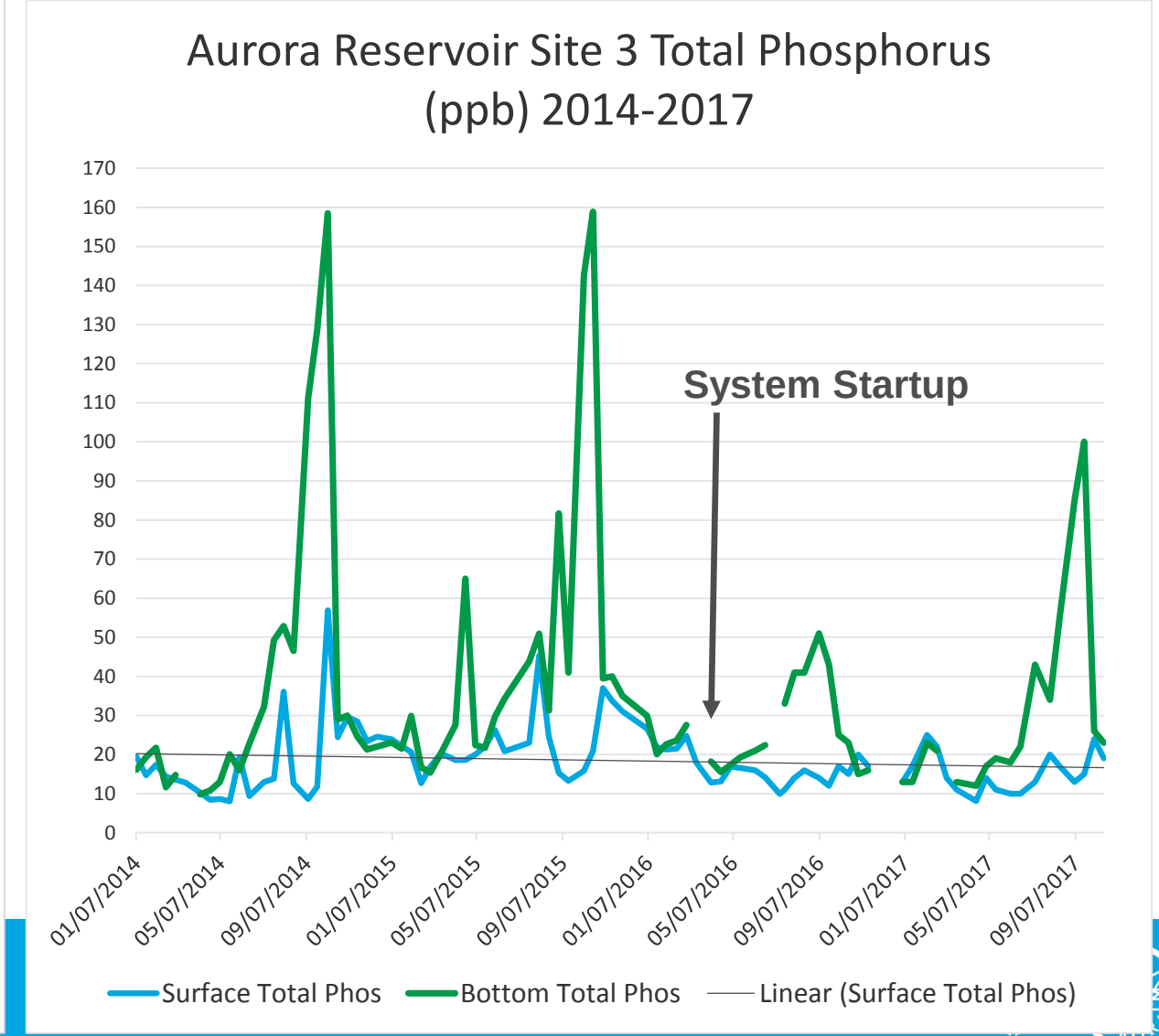
- Goal was to feed enough oxygen into hypolimnion to keep dissolved oxygen close to surface saturation levels
- “Turn up” capability (max flow of 235 lbs./hour) allowed us to meet that goal even during first summer of operation
- As expected, less oxygen was used to meet that goal during the second season of operation (max flow of 185 lbs./hour utilized)
- Oxygen cost:
  - $39,000 (2016)
  - $32,000 (2017)



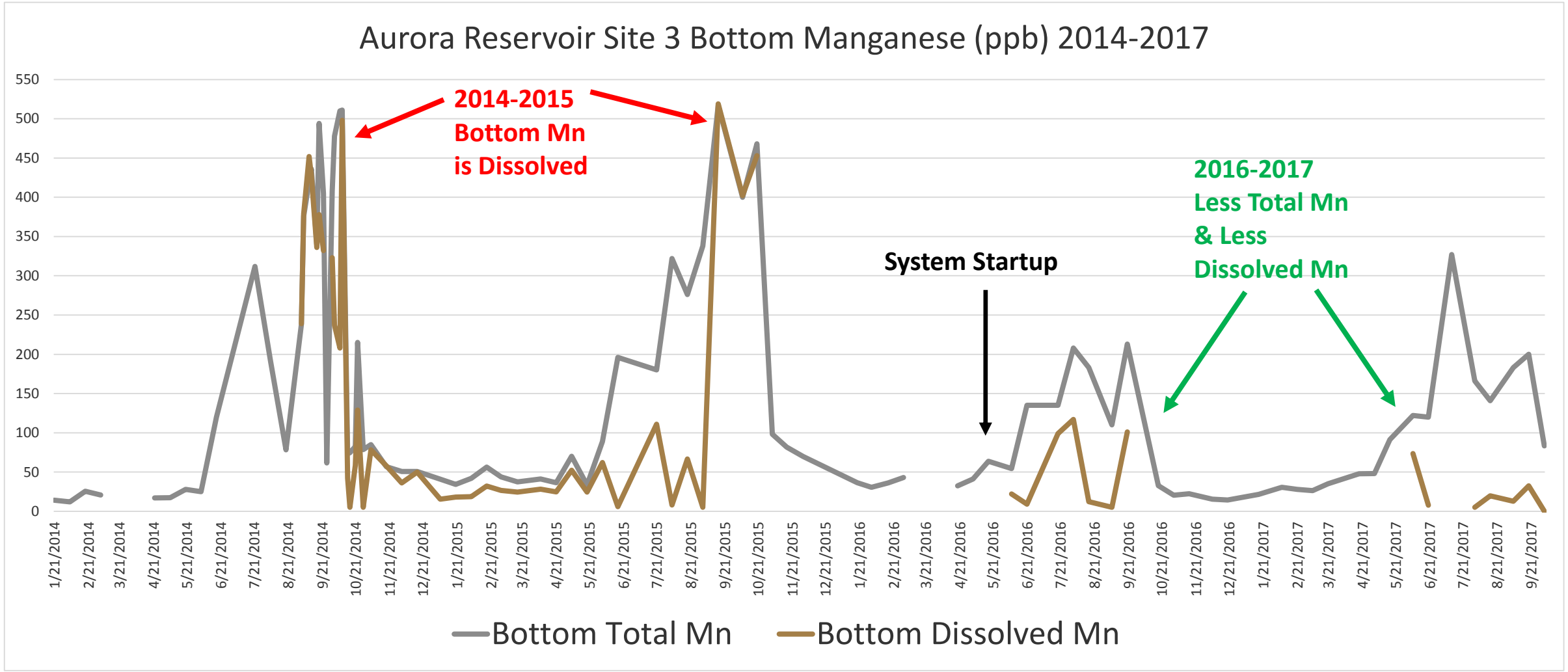
Goal # 2: Less internal release of phosphorus

- Reduction observed in both soluble reactive and total phosphorus

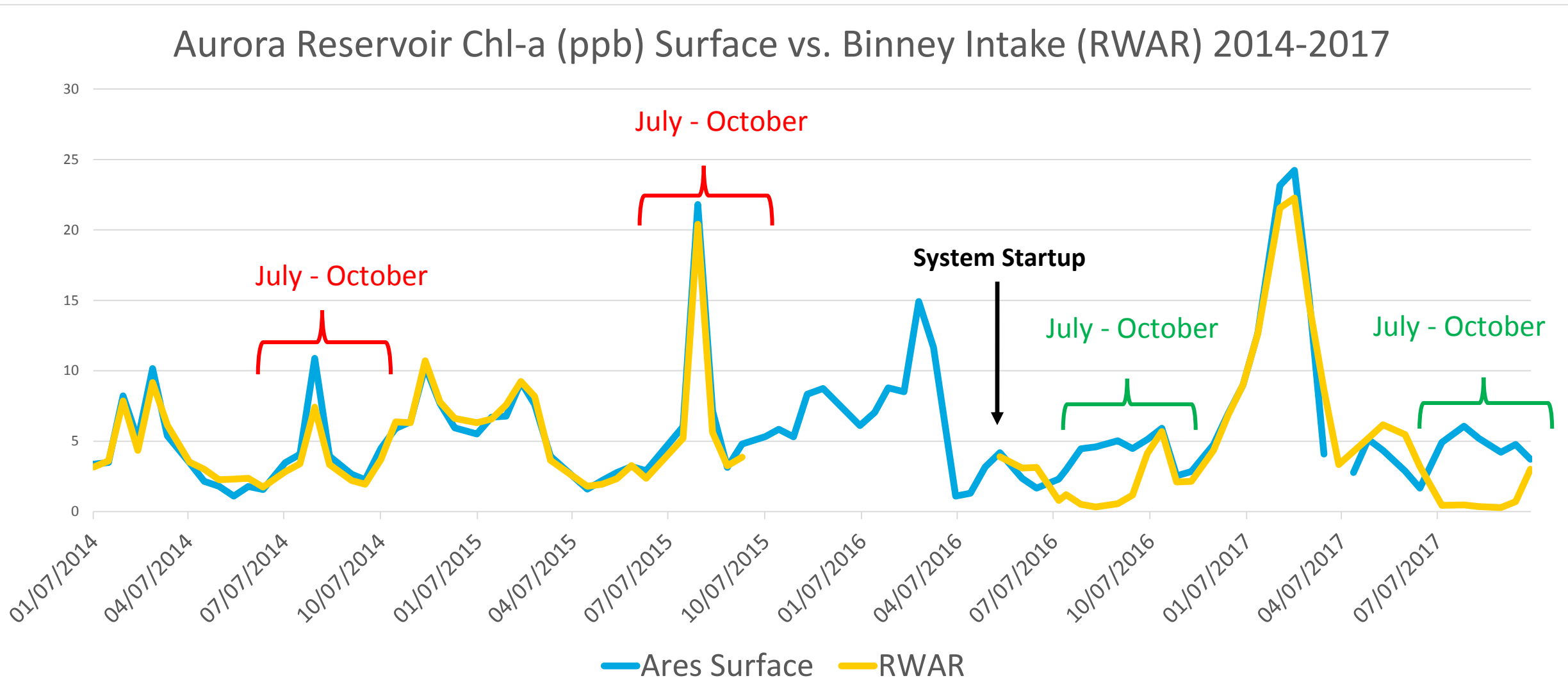




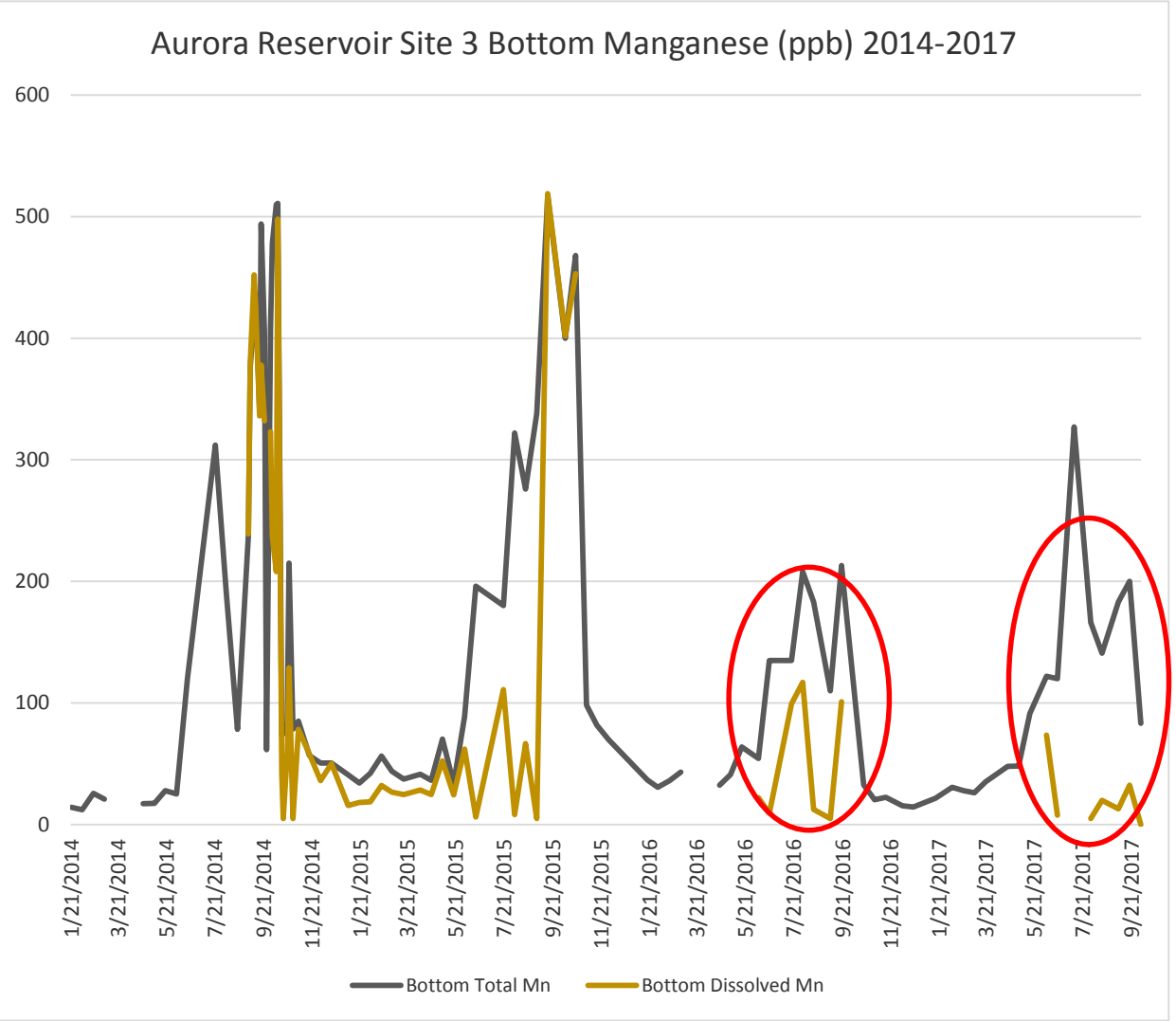
Goal #3: Better water quality for water treatment - Manganese

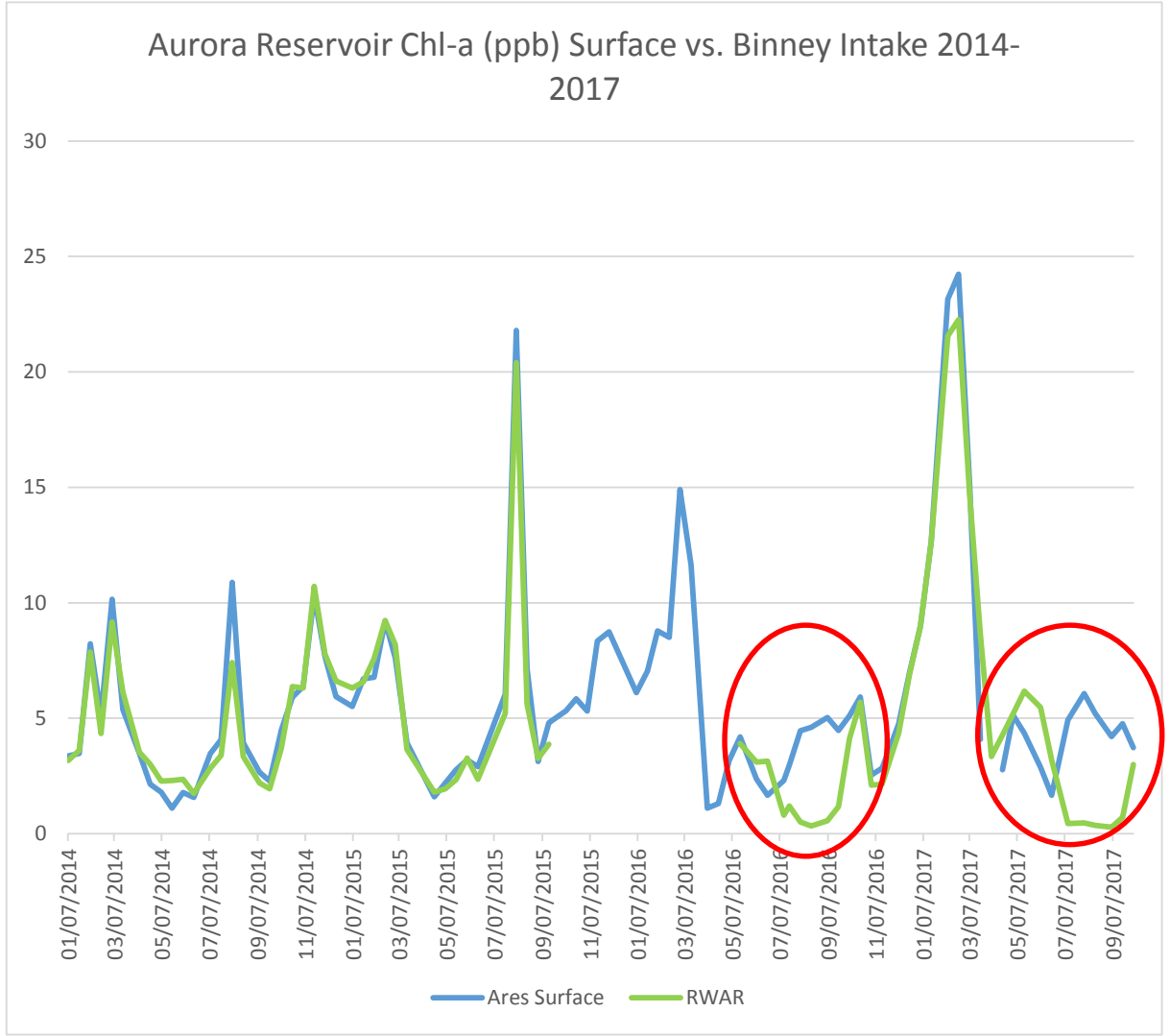


Goal #3: Better water quality for water treatment – Chlorophyll-a



Did this shift in water quality actually help treatment?





Treatment benefits observed during the first two years of operation

- Dramatic decrease in taste and odor complaints
  - Complaints reduced from approximately 100 per summer to less than five total since the system was started
  - Cost savings of approximately $350,000 per year in Granular Activated Carbon
- Dramatic decrease in potassium permanganate pre-oxidant dose
  - Manganese that is released from bottom sediments is now almost entirely pre-oxidized by system in the reservoir rather than depending on chemical oxidation at the WTP
  - Cost savings of potassium permanganate: (2016) $15,000 (2017) $80,000
- Dramatic decrease in coagulant chemical use
  - Lower algae levels and TOC in bottom water during summer allowed for drastic chemical cuts
  - Cost savings of coagulant chemicals: (2016) $45,000 (2017) $83,000

Conclusions

Summary of project benefits

- Over the past two years, maintaining dissolved oxygen levels in the hypolimnion with the LOX ballasted linear diffuser, allowed us to:
  - Save approximately $850,000 in treatment chemicals and granular activated carbon costs
  - Answer approximately 200 fewer taste odor complaint calls
  - Spend considerably less time evaluating and making treatment related chemical changes
  - Blend in Aurora Reservoir water at the Wemlinger WPF in the middle of summer 2017 with no T&O complaints
  - Observe reduced soluble reactive and total phosphorus internal loading
  - Have great hope that these first two successful years are only the beginning of the healing and restoration in Aurora Reservoir's new life!